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Study the presence of toxic species of phytoplankton and red tide Phenomenon in northern part of Lattakia coastal water (Syria)

Feirouz Darwich

ABSTRACT

Seasonal changes in toxic phytoplankton abundance were investigated in this study. Quantitative and qualitative phytoplankton and nutrient analysis were carried out in 2018 at two sampling stations this research was carried out in northern part of Lattakia coastal waters in the northeastern Mediterranean coast of Syria. Sampling was performed monthly from January to December of 2018. Thirty two (32) phytoplankton species observed in this study can be considered toxic or potentially harmful in high concentration. The phytoplankton spring bloom in northern part of Lattakia was formed by toxic species of diatoms *Pseudo-nitzschia delicatissima*, *Nitzschia closterium*, *Leptocylindrus minimus*, *Leptocylindrus danicus*, *Chaetocheros curvisetus.*

Key words: phytoplankton, Mediterranean Sea, Harmful algae blooms (HABs), Red tide.

1. INTRODUCTION

Algae are unicellular microscopic plants that can be considered the foundation of life. A harmful algal bloom (HAB) is defined as a bloom that has deleterious effects on plants, animals or humans (Anderson, 1994; Anderson & Gilbert, 2002; Anderson et al., 2013). Phytoplankton blooms, micro-algal blooms, toxic algae, red tides or harmful algae are all terms for these naturally occurring phenomena. HABs can deplete the oxygen and block the sunlight that other organisms need to live, and some HABs release toxins that are dangerous to animals and humans. Marine algal toxins are responsible for an array of human illnesses associated with the consumption of contaminated seafood and exposure to aerosolized toxins.

On a global scale, the rate of coastal urbanization will increase rapidly in the next decades, and in combination with climate change is projected to result in an increased risk of coastal eutrophication (Darwich, 2006; Kroeze et al., 2013; Parsons & Dortch, 2017; Ben-Gharbia et al., 2016). Sewage inputs

from coastal cities that are transported directly to coastal waters can act synergistically with land-based sources and river run-off causing high levels of nutrients (Turkoglu, 2010). Worldwide eutrophication has led to phytoplankton abundance and biomass increase while more coastal harmful algal blooms (HABs) with more toxic species, have been linked with eutrophication phenomena (Arff & Miguez, 2016). Numerous examples of linkages between nutrient loading and coastal toxic phytoplankton blooms along the coast of eastern Mediterranean include the involvement of harmful species of diatoms and dinoflagellates (Genovesi et al., 2015; Hachani et al., 2018; Genitsaris et al., 2019).

The location of the research area is considered as touristic place, and is heavily populated during summer and under threat from pollutants coming from agriculture areas and industrial facilities. The input from the Streamlet and outfall of sewage canal which serve the around area.

Despite the growing concerns of the citizens and authorities on the water quality of the Lattakia city, only scarce and isolated studies have been published on the abundance and dynamics of phytoplankton community (Darwich, 1999; Hamoud, 2001; Darwich & Suliman, 2012; Darwich, 2013; Darwich, 2021; Darwich, 2022). However, comprehensive studies on the occurrence of HABs and red tides phenomena are lacking for the Syrian coastal waters.

Therefore, this study was carried out to investigate the seasonal variations of the toxic phytoplankton blooms (species diversity, dominance, and abundance) and observation of the red tide phenomena at two stations in the northern part of Lattakia city in relation to changes in physic-chemical factors.

2. MATERIALS AND METHODS

The study was carried out at two stations in the coastal area of Eben Hani, located in northern part of Lattakia city, northeastern Mediterranean (Fig. 1). Samples were collected at monthly interval from January to December in 2018. The area of study extends for a distance of 5 km and, the choice of sampling stations was conducted according to the gradient of anthropogenic activities. Two stations were chosen with different environmental characteristics:

Station 1 (ST1): is located at 50 m from the discharge of stream, where the depth of water column is about 4m. The area is influenced by sewer sanitation which serves the neighboring villages, and the discharge of fertilizer agriculture waste.

Station 2 (ST2): is located 2 km from the shore, where the depth of the water column exceeds 20 m and opened directly to the sea. The location is affected with discharge of sewage water, which serves the touristic hotels and houses around.

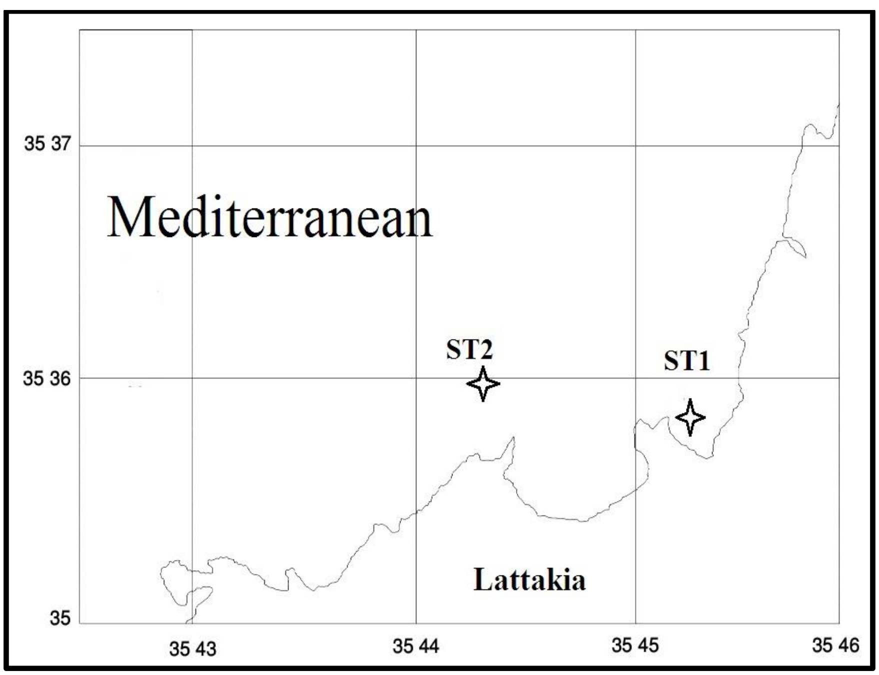

Figure 1. Location of sampling stations

Surface water samples were collected on monthly basis in the morning from January to December 2018 at both stations. Surface water temperature (SST) and salinity (SSS) were measured by using YSI model YSI. Standard phytoplankton net with 20-µm mesh

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size was used for phytoplankton sampling. Phytoplankton. Water samples were immediately fixed with Lugols's solution in order to estimate the abundance of phytoplankton in water samples using Utermoehl's method (1958). Species were determined based on international taxonomic references (Sournia, 1986; Starmach, 1989).

3. RESULTS AND DISCUSSION

Environmental Conditions

Seasonal changes in temperature and salinity in both sampling stations are shown in figure 2. The lowest temperature (17 °C) was recorded in January, whereas the highest in August was 29.5 °C. Salinity decreased to the lowest levels (38%) in winter due to rain and freshwater input, and reached the highest values (41.2%) in summer due to the lack of rain and high evaporation (Darwich, 2021, 2022; Darwich & Alakash, 2021).

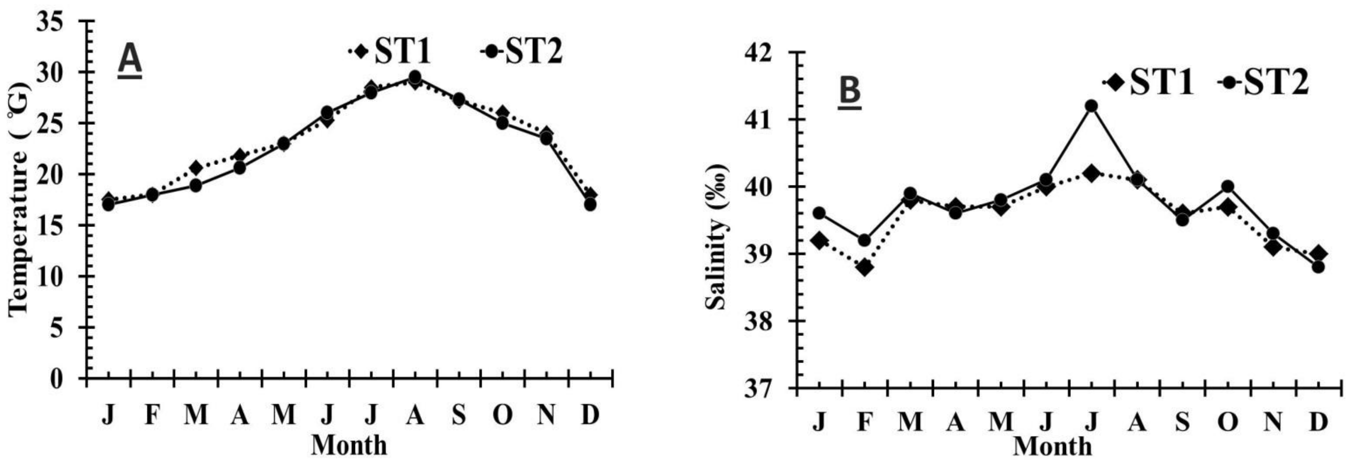

Fig. 2 Variations of temperature (A) and Salinity (B) during research period

Toxic Phytoplankton Blooms

The research area is under the influence of land based input, clear response of phytoplankton was detected in terms of biomass, abundance and diversity due to these effects (Hamoud 2001; Darwich & Suliman, 2010; Darwich, 2013; Darwich, 2021). Nutrient concentrations in this coastal area reached relative high concentration (Darwich, 2021). The high nutrient concentrations due to source stations, where the sewage outfall and the fertilizer agriculture waste are charged, allow the formation of eutrophic conditions. Besides, the results of toxic phytoplankton community structure and abundance support this suggestion (Darwich, 2021; 2022).

Toxic phytoplankton cell number showed significant fluctuation in different seasons at both stations (Figures 3, A, B, C, D). The lowest cell number of toxic phytoplankton were found in winter but an increase started in March due to the bloom of toxic specie *Ostreopsis siamensis* (Fig. 3, C, D). The number of toxic phytoplankton species was high in spring. The diversity index declined to a minimum level when one or few species were dominant in phytoplankton blooms (Hallegraeff, 1995; Turkoglu & Temporal, 2010; Hillebrand, 2017; Darwich, 2021; Darwich & Alakash, 2021).The phytoplankton spring bloom at both stations were formed by toxic species of diatoms *Pseudo-nitzschia delicatissima, Nitzschia closterium, Leptocylindrus minimus, Leptocylindrus danicus, Chaetocheros curvisetus* (Figures 3, A, B), all These species are uncommon during the spring blooms of phytoplankton which was not recorded in the previous study of this region (Darwich, 2021; Darwich & Alakash, 2021). The dinoflagellates: *Dinophysis caudata*, *Ceratium furca*, *Ceratium fusus*, *Alexandrium tamarense, prorocentrum micans* and *p. lima* appeared in May and June, as their appearance coincided a rise with temperature water, this is agreed with the different studies at the studied area and different coastal water at the eastern part of Mediterranean (Vila et al., 2014; Nikolaidis et al., 2015; 2019) and the previous study of this region (Hamoud, 2001; Darwich & Alakash., 2021). The known harmful species *Rhizosolenia alata*, *R. calcar-avis*, *Protoperidinium depressum*, *Ceratium furca*, *C. fusus* and Noctiluca scintillans were detected in relatively low abundances (Figures 3 A, B, C, D). Some of these plankton species have been previously reported in the Syrian coastal waters (Darwich & AlMerei, 2020; Darwich & Alakash, 2021; Darwich, 2022; 2021).

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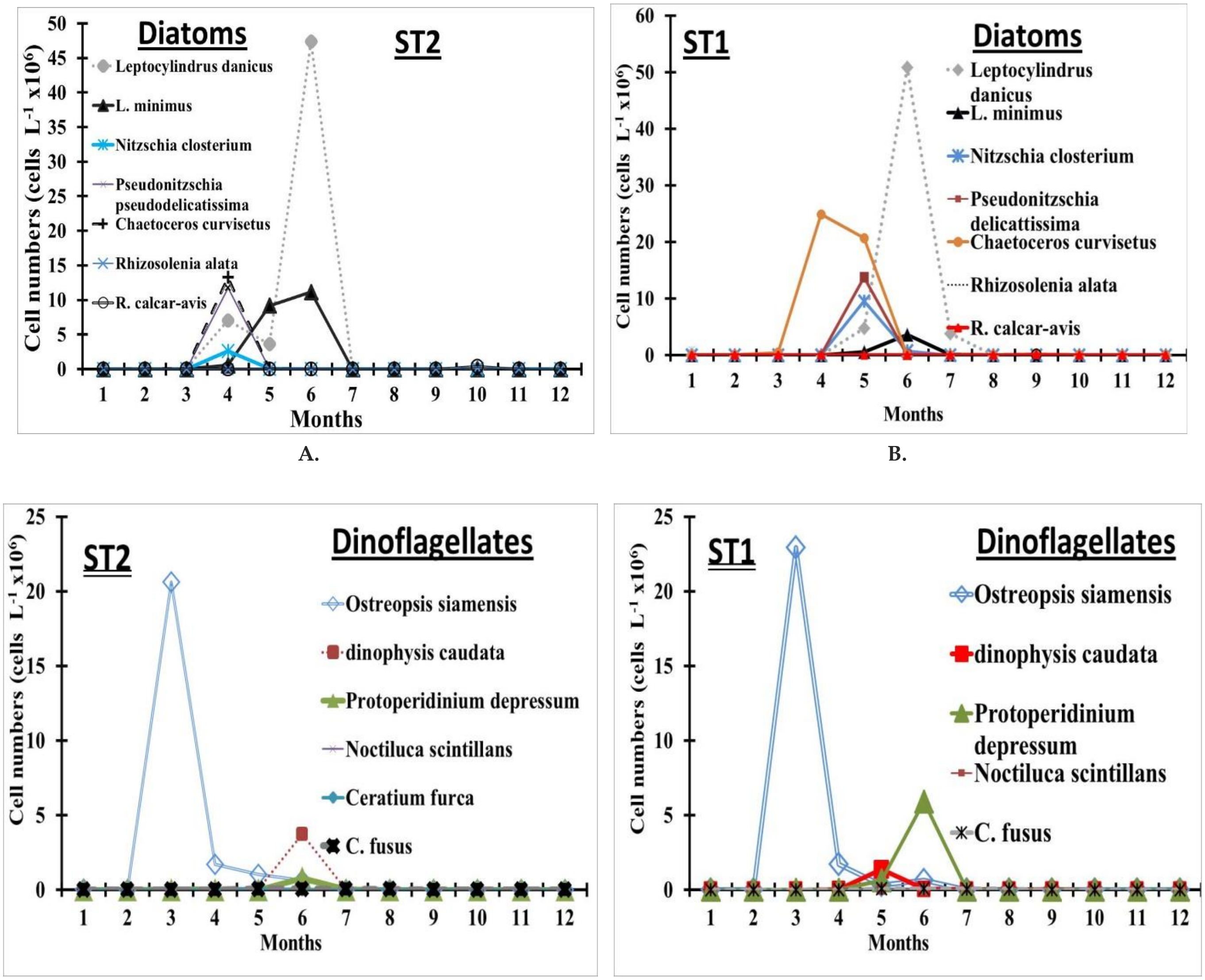

Fig (3). Monthly variations of the abundance of Toxic species of diatoms (A,B)and dinoflagellates(C, D) from January to December 2018 at two Stations (ST1, ST2).

Red Tides

In this study, several forming red tides species were documented over a temperature range of 20 to 26°C, and a salinity range of 39 to 40‰. The red tide forming species terminated its growth in our study area by the increase of water temperature spring above 27 ◦C, as in many other studies (Genovesi et al., 2015; Cibic et al., 2018), but temperature did not correlate with the start of its growth (Simboura et al., 2016).

Potentially forming red tides species were detected in this study mostly in spring and early summer (32 species) at both sites (Table 1), but their frequency and their density were the highest at St.1 i.e. *Pseudo-nitzschia delicatissima, Leptocylindrus danicus, Chaetocheros curvisetus, Ostreopsis siamensis*, due to the direct influence of sewer sanitation, and the discharge of fertilizer agriculture waste. All register toxic bloom of all recorded species in our study are known of their production of different toxins and transmitted by either molluscs or fish. Paralytic Shellfish Poisoning (PSP) is due to the consumption of bivalves or planktivorous fish while Diarrhetic Shellfish Poisoning(DSP), Amnesic Shellfish Poisoning (ASP), Neurotoxic Shellfish Poisoning(NSP), and Azaspiracid Shellfish Poisoning (AZP) Poisons (PSP,) Paly toxin (PLTX) which may cause death of many marine organisms including human (Zingone et al., 2006; Heisler et al., 2011; Morris et al., 2014; Moncheva et al., 2011; Saab & Hassoun, 2017; Pizarro et al., 2018; Armengol et al., 2019).

Many studies in different Area of Syrian coastal waters showed that most of the species responsible for the red tide phenomenon have appeared on the Syrian coast, but mostly with narrow limits, both in the city of Lattakia (port - Southern Corniche - Afamea - Higher Institute for Marine Research - Sakiyat Mikael) (Darwich, 2013; Hamoud, 2001; Darwich, 2022), or in the beach of Banias (Darwich, 1999; Darwich & AlMerei., 2020), and in the beach of Tartous (Hammoud et al., 2015) and no poisoning incidents or waters discoloring were recorded as a result of the spread of these species.

Table 1. List of harmful marine phytoplankton species of Dinoflagellates and diatoms responsible for the phenomenon of red tides, the type of toxins they produce and their presence in the Syrian coastal waters (Banias\Darwich, 1998; Darwich & AlMerei, 2020; Tartus\Salloum, 2015, and Lattakia/ present study). V=very abundant, 61-100%; A=abundant, 41-60%; C=common, 16-40%; R=rare, 1-15%; X= present occasionally. DSP: Diarrhetic Shellfish Poisoning, PSP: Paralytic Poisoning Shellfish, ASP: Amnesic Shellfish Poisoning, PLTX: Palytoxin.

Species	Occurrence			Category
<u>**Dinoflagellates**</u>	**Banias**	**Tartus**	**Lattakia**	
Alexandrumminutum	**R**	**X**	**R**	**PSP**
A. tamarance	**C**	**C**	**R**	**PSP**
Dinophysisacuminata	**C**	*	**C**	**DSP**
D.acuta	**C**	**R**	**C**	**DSP**
D.caudata	**C**	**C**	**R**	**DSP**
Gonyaulauspolygramma	**R**	**R**	**R**	**PSP**
Heterocapsa minima	**C**	**R**	**X**	**Unknown toxicity**
Noctilucascintillans	**C**	**R**	**R**	**PSP**
Ostreopsisovata	**-**	**-**	**R**	**PLTX**
O. siamensis	**-**	**-**	**VA**	**PLTX**
Prorocentrum lima	**C**	*	**R**	**DSP**
P. micans	**VA**	**R**	**R**	**DSP**
P. minimum	**C**	*	**R**	**DSP**
Protoperidiniumdepressum	**R**	**R**	**R**	**Unknown toxicity**
Ceratiumfurca	**C**	**C**	**C**	**Unknown toxicity**
Ceratiumtripos	*	*	**R**	**Unknown toxicity**
Prorocentrum lima	**R**	**R**	**R**	**DSP**

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P. micans	**VA**	**R**	**X**	**DSP**
P. minimum	**X**	**X**	**X**	**DSP**
Diatoms				
Nitzschiaclosterium	**C**	**R**		**Unknown toxicity**
Chaetoceroscurvisetus	**R**	**R**	**R**	**Unknown toxicity**
Ch. similss				
Lyptocylindrusdanicus	**A**	**-**	**VA**	**PSP**
			VA	**PSP**
L. minimus	**X**	**R**	**A**	**PSP**
Nitzschiaclosterium	**A**	**R**	**C**	**PSP**
Pseudonitzschiadelicatissima			**VA**	**ASP**
P. pungens	**-**	**-**	**R**	**ASP**
p. seriata			**VA**	**ASP**
Pseudonitzschia sp.	**R**		**C**	**ASP**
Rhizosolenia cf. imbricata	**R**	**R**	**R**	**Unknown toxicity**
Guinardiastriata (=Rhizosoleniastolterfothii)	**R**	**R**	**C**	**Unknown toxicity**
Skeletonemacostatum	**C**	**R**	**R**	**Unknown toxicity**

4. CONCLUSION

During the study period, analysis of the monthly water samples from the urban coastal of Northern part of Lattakia provided an outlook of the effects of eutrophication in this Mediterranean urban environment with further implications on marine eutrophication research and coastal management. Many of toxic species responsible for the phenomenon of red tide were registered. For many toxic species, their presence even in low numbers is considered harmful (Hansen et al., 2001). Thirty two phytoplankton species observed in this study can be considered toxic or potentially harmful in high concentration. However, there is always the threat of increasing eutrophication from industrial and domestic effluents that could enhance the growth of these species particularly the in the studying area.

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Ethical approval

Phytoplankton species from northern part of Lattakia coastal water (Syria) were recorded in the study. The ethical guidelines are followed in the study for sample collection & identification.

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This study has not received any external funding.

Conflicts of interests
The authors declare that there are no conflicts of interests.

Data and materials availability
All data associated with this study are present in the paper.

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